# Grade Stabilization Structure (No.) 410

## DEFINITION

A structure used to control the channel grade in natural or constructed watercourses.

## PURPOSES

To stabilize grade, reduce gully erosion in natural or constructed watercourses, prevent the formation or advance of gullies and to improve water quality.

## CONDITIONS WHERE PRACTICE APPLIES

Where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion.

## CRITERIA

### General Criteria

Grade stabilization structures shall be planned, designed, and installed to meet all federal, state, local and tribal laws and regulations.

The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that will stabilize the channel and prevent upstream head cutting.

Grade stabilization structures shall be designed according to the principles set forth in the National Engineering Handbook, Part 650, Engineering Field Handbook, or other applicable NRCS publications and reports.

Earth embankments and auxiliary spillways of structures must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow without overtopping the embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable embankment for anticipated flow conditions. Discharge from the structure shall be controlled to minimize crop damage resulting from flow detention.

Structures installed in natural channels shall be compatible with the fluvial geomorphic conditions at the site to ensure the stability of the structure.

Sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout.

Grade stabilization structures are potentially hazardous and precautions shall be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be installed as needed.

Fence shall be installed, as needed, to control access and exclude livestock and other traffic that may damage the structure.

The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded, sodded or otherwise protected as necessary to prevent erosion.

All areas disturbed by the construction shall be re-vegetated according to Critical Area Planting, NRCS Conservation Practice Standard Code 342.

Use vegetation adapted to the site that will accomplish the desired purpose. Preference shall be given to native species in order to reduce the introduction of invasive plant species; provide management of existing invasive species; and minimize the economic, ecological, and human health impacts that invasive species may cause. If native plant materials are not adaptable or proven effective for the planned use, then non-native species may be used. Refer to the Field Office Technical Guide, Section II, Invasive Plant Species, for plant materials identified as invasive species.

### General Criteria for Embankments

The minimum sum of the upstream and downstream side slopes of the settled embankment shall not be less than five horizontal to one vertical with neither slope steeper than 2:1. Slopes shall be designed to be stable in all cases.

The fill height shall be increased by a minimum of 5% for mineral foundation soil and 33% for organic foundation soil to allow for settlement, except where detailed soil testing and laboratory analysis show a lesser amount is adequate.

The minimum top width for embankments is shown in Table 1.

| TABLE 1<br>Minimum Top Width Requirements for Embankments | |
|---|---|
| Fill Height | Effective Top Width |
| *ft (m)* | *ft (m)* |
| 0-5 (0-1.5) | 3 (0.9) |
| 5-10 (1.5-3.0) | 6 (1.8) |
| 10-15 (3.0-4.5) | 8 (2.4) |

**General Criteria for Pipe Conduits**

The diameter of the pipe shall not be less than 8 inches (20 cm).

The following pipe materials are acceptable: cast-iron, steel, corrugated steel or aluminum, concrete, plastic, and cast-in-place reinforced concrete. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet resistant materials or protected by coating or shielding.

Inlets and outlets shall be structurally sound and made from materials compatible with the pipe.

Drainage diaphragms meeting the requirements stated in Pond, NRCS Conservation Practice Standard Code 378, shall be used to prevent piping unless all of the following conditions exist:

1. The conduit is corrugated pipe and has a diameter of 18 inches (46 cm) or less.

2. The maximum hydraulic head on the pipe is 6 feet (1.8 m) or less.

3. The soils used for backfilling have good to excellent piping resistance. (Ref., National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 4.)

4. The designer has evidence that pipes in similar soil and site conditions have functioned satisfactorily without drainage diaphragms.

Watertight coupling bands are required for all pipes designed for pressure flow. Inlets of closed conduit spillways designed for pressure flow are to have an anti-vortex device.

An appropriate trash guard shall be installed at the inlet, as necessary, to prevent clogging of the conduit.

Pipe strength shall not be less than that of the grades indicated in Table 2 for plastic pipe and Table 3 for corrugated aluminum and steel pipe.

| TABLE 2<br>Acceptable PVC and PE Pipe for use in Grade Stabilization Structures 1/ 2/ | | |
|---|---|---|
| Nominal Pipe Size | Material and Schedule or Wall Type | Maximum Depth of Fill Over Pipe |
| *in (cm)* | | *ft (m)* |
| 8–12 (20-30) | PVC 40 | 10 (3) |
| 8–12 (20-30) | PVC 80 | 15 (4.5) |
| 8-24 (20-60) | PE single | 20 (6) |
| 8-60 (20-155) | PE double | 20 (6) |

1/ Polyvinyl chloride (PVC) pipe, PVC 1120 or PVC 1220, conforming to ASTM D 1785

2/ Polyethylene (PE) pipe will conform to one or more of the following standards: ASTM F 405, ASTM F 667, AASHTO M 252 or AASHTO M 294.

| TABLE 3 | | |
|---|---|---|
| Gage or Thickness Required: Corrugated Metal Pipe for Fill Heights above Pipe not to Exceed 15 feet (4.5 m) | | |
| Pipe Diameter | Steel 1/ | Aluminum 2/ |
| | Minimum gage | Minimum thickness |
| *in (cm)* | | *in (mm)* |
| 12-24 (30-60) | 16 | 0.06 (1.5) |
| 30 (75) | 14 | 0.075 (1.9) |
| 36 (95) | 14 | 0.075 (1.9) |
| 42 (110) | 14 | XXX |
| 48 (125) | 14 | XXX |

1/ For steel CMP:
a. Maximum pipe diameter is 48 in (125 cm)
b. 2 2/3 X 1/2 (6.8 X 1.3 cm) corrugations except 3X1 (7.6 X 2.4 cm) corrugations for over 36 in (92 cm) in diameter.

2/ For aluminum CMP with 2 2/3X1/2 (6.8 X 1.3 cm) corrugations:
a. Pipe may be riveted or helical fabrication.
b. Pipe shall not be placed in soils having a pH less than 4 nor greater than 9.
c. Max. allowed pipe diam. is 36 in (92 cm).

**General Criteria for Auxiliary Spillways**

An auxiliary spillway must be provided for all closed conduit structures except as allowed for embankment dams and for drop boxes to road culverts. Full flow open structures such as chute or drop spillway structures do not require an auxiliary spillway if the principal spillway can safely pass the minimum total capacity design storm peak flow.

Constructed spillways shall be trapezoidal and will be located in undisturbed or compacted earth. The side slopes shall be 2 1/2:1 or flatter. The auxiliary spillway shall have a minimum bottom width of 8 ft. (2.4 m) and a minimum depth of 1.0 ft. (0.3 m). The minimum elevation of the settled fill shall be 0.5 ft. (0.15 m) above the water surface with the auxiliary spillway flowing at design depth.

The exit channel shall provide for passage of the design flow at a safe velocity to a point downstream of where the embankment will not be endangered. For further information, see the National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 11, pages 11-17 through 11-22.

**Additional Criteria for Embankment Dams**

Embankment dams are defined as earth fills greater than 3 feet (0.9m) in height that have a permanent pool or which are designed to pass the design storm peak inflow through the principal and auxiliary spillways with reduction for storage. Embankment dams this practice applies to are low hazard (class a) dams that have a product of storage times the effective height of the dam of less than 3,000 ac-ft$^2$ (1,300, 000 m$^4$) and an effective height of 35 feet (10.5 m) or less. The effective height of the dam is the difference in elevation between the auxiliary spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit.

Embankment dams with a settled fill height of less than 15 ft (4.5 m) and 10-year frequency, 24-hour storm runoff less than 10 ac-ft (12,000 m$^3$), shall be designed to control a minimum of the 10-year frequency, 24-hour storm without overtopping. The mechanical spillway, regardless of size, may be considered in design and an auxiliary spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment will be designed to meet the requirements for Water and Sediment Control Basin, NRCS Conservation Practice Standard Code 638.

Other embankment dams shall meet or exceed the requirements specified for Pond, NRCS Conservation Practice Standard Code 378.

**Additional Criteria for Full-Flow Open Structures**

Full-flow open structures are those which are designed to pass the design storm peak inflow through the principal and auxiliary spillways without reduction for storage. Examples are drop, chute, and box inlet spillways. The minimum capacity shall be the 24-hour duration design storm of the frequency shown in Table **4**. Structures must not create unstable conditions upstream or downstream. Provisions must be made to ensure safe reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 ft (1.2 m) or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to road culverts shall be 1.25 times the capacity required by the responsible drain or road authority, the existing culvert capacity or as specified in Table 4, as applicable, less any reduction because of detention storage.

| TABLE 4 | | | |
|---|---|---|---|
| Full-flow Open Structure Design Criteria [1/] [2/] | | | |
| Maximum Drainage Area | Maximum Vertical Drop | Frequency of Minimum Design, 24-hour Duration Storm | |
| | | Principal Spillway Capacity | Total Capacity |
| *acres (ha)* | *ft (m)* | *year* | *year* |
| 20 (8) | All | 2 | 10 |
| 100 (40) | All | 5 | 25 |
| 450 (180) | 5 (1.5) | 5 | 10 |
| 900 ((360) | 10 (3) | 10 | 25 |

1/ If site conditions exceed those shown in Table 4, the minimum design 24-hour storm frequencies are 25 years for the principal spillway and 100 years for the total capacity.

2/ For geosynthetic chutes with a maximum 10-year, 24-hour frequency design storm of 80 cfs (2.3 $m^3/s$) and a maximum drop of 15 ft (4.5 m), the minimum design for total capacity shall be for a 10-year frequency, 24-hour duration storm.

**Additional Criteria for Island-Type Structures**

Island-type structures are a special case of the full-flow structure. For island-type structures, out of bank flooding can be tolerated. The minimum capacity of the principal spillway of an island-type structure shall equal the capacity of the downstream channel. In no case shall it be less than the 2-year, 24-hour storm or the design drainage curve runoff. The minimum auxiliary spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 4 for total capacity without overtopping the headwall extensions of the principal spillway. Provision must be made for safe reentry of bypassed flow as necessary.

**Additional Criteria for Side-Inlet Drainage Structures**

Side inlet drainage structures are used to lower surface water from field elevations or lateral channels into constructed drainage channels. The design criteria for minimum capacity of open-weir or pipe side inlet drainage structures are shown in Table 5.

| TABLE 5 | | | |
|---|---|---|---|
| Side Inlet Structure Hydraulic Design Criteria [1/] [2/] [3/] [4/] | | | |
| Maximum Drainage Area | Maximum Vertical Drop | Frequency of Minimum Design, 24-hour Duration Storm | |
| | | Principal Spillway Capacity | Total Capacity |
| *acres (ha)* | *ft (m)* | *year* | *year* |
| 20 (8) | All | 2 | 10 |
| 100 (40) | All | 5 | 25 |
| 450 (180) | 5 (1.5) | 2 | 10 |
| 450 (180) | 10 (3) | 5 | 10 |
| 900 (360) | 10 (3) | 5 | 25 |

1/ If site conditions exceed those shown in Table 5, the minimum design for total capacity shall be for a 50-year frequency, 24-hour duration storm.

2/ If the entire structure drainage area has an average slope of less than 0.5%, and the drainage area within 500 ft (150 m) of the structure has an average slope of less than 0.5%, side inlet principal spillways may be designed to pass a peak discharge of 0.17 cfs/ac (0.011 $m^3/s/ha$) of drainage area.

3/ A 10 in (25 cm) minimum diameter principal spillway pipe with at least 1.5 ft (0.45 m) stage may be used for watersheds less than 20 ac (8 ha) in size.

4/ For geosynthetic chutes with a maximum 10-year, 24-hour frequency design storm of 80 cfs (2.3 $m^3/s$) and a maximum drop of 15 ft. (4.5 m), the minimum design for total capacity shall be for a 10-year frequency, 24-hour duration storm.

## CONSIDERATIONS

Consider the potential effects of installation and operation of a grade stabilization structure on the cultural, archeological, historic and economic resources.

Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

Consideration should be given to the effect a structure will have on the aquatic habitat of a channel. If the channel supports fish, the effect of a structure on the passage of fish should be considered. Consider maintaining or improving fish and wildlife habitat.

## PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

Support data documentation requirements are as follows:

- Inventory and evaluation records
  - Assistance notes or special report
- Survey notes, where applicable
  - Design survey
  - Construction layout survey
  - Construction check survey
- Design records
  - Physical data, functional requirements and site constraints, where applicable
  - Soils/subsurface investigation report, where applicable
- Design and quantity calculations
- Construction drawings/specifications with:
  - Location map
  - "Designed by" and "Checked by" names or initials
  - Approval signature
  - Job class designation
  - Initials from preconstruction conference
  - As-built notes
- Construction inspection records
  - Assistance notes or separate inspection records
  - Construction approval signature
- Record of any variances approved, where applicable
- Record of approvals of in-field changes affecting function and/or job class, where applicable.

## OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) plan shall be developed for this practice. The O&M plan shall be consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for the design.

## REFERENCES

USDA-NRCS, National Engineering Handbook, Part 650, Engineering Field Handbook

USDA-NRCS, Technical Release No. 55, Urban Hydrology for Small Watersheds